Simulation Modeling of Wilderness Recreation Use

Final Report #: 03-IA-11222044-076

Simulation Modeling of Wilderness Recreation Use: Final Report

Steve Lawson and Robert Manning

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Study Objectives

Currently, two related approaches to simulation modeling are being applied in park and wilderness management. Manning, Lawson, and associates use the object-oriented dynamic simulation package, Extend, to code and model current visitor use travel patterns and levels (e.g., Lawson et al. 2003, Wang & Manning 1999). Gimblett, Itami, and associates use RBSim, a simulation package that combines artificial intelligence and GIS technologies to predict the behavior of park and wilderness visitors (e.g., Daniel & Gimblett 2000). The purpose of this research is to explore alternative approaches and applications of simulation modeling to park and wilderness management. Specifically, existing data concerning visitor use of the Humphrey's Basin area of the Inyo National Forest were used to develop a computer simulation model using the Extend approach to computer simulation modeling (hereafter referred to as the "Extend simulation model"). The Extend model provides outputs that allow for comparisons with a similar model developed using the RBSim approach.

The following section of this report describes the methods used to develop the Extend simulation model. The final section of the report presents study results that illustrate the types of visitor use information that can be generated using computer simulation modeling. In addition, the final section of the report includes an example of how computer simulation modeling can be used to estimate the effectiveness of alternative management strategies designed to improve the quality of visitors' experiences. This project constitutes one element of a larger effort to research and develop simulation modeling approaches that are readily available to park and wilderness planners and managers.

Study Methods

Data used to construct the Extend computer simulation model were provided by Randy Gimblett of the University of Arizona. The data include the reported trip itineraries of 459 groups that visited Humphrey's Basin during the 1999 visitor use season. The itinerary data include the starting date and location (i.e., trailhead) of each group's visit to Humphrey's Basin, the location of each campground the group stayed in during their trip and the corresponding date, and the ending date and location (i.e., trailhead) of each group's visit to the area.

Preliminary analyses of the data were conducted to guide the design of the Extend simulation model. GIS analyses were performed to cluster individual camping locations into "camping encounter zones" and to develop a trail network to link the camping zones to one another (Figure 1 presents a map of the camping encounter zones). Camping locations contained within a single camping zone were considered to be close enough that two groups camping within the same zone on the same night would have a "camping encounter" with one another. Statistical analyses were conducted to test for variations in trip itineraries between large groups and small groups, and by periods of the visitor use season. These analyses were perfomed to determine whether separate tables of trip itineraries would be needed for small groups and large groups, and for different periods of the visitor use season. The tests indicated no significant differences. Consequently, a single table of trip itineraries was used for small and large groups, throughout the entire simulation period. In addition, statistical analyses were performed to test for variations in the number of trip starts by day of the week and trailhead, to determine whether different headways rates were needed for different days of the week. No significant differences

were found in the average number of weekend and weekday trip starts. Therefore, the distribution of the number of simulated trip starts per day varied around the same mean value for both weekend days and weekdays. Lastly, the original itineraries data were reformatted and imported into Extend.

Extend Simulation Model Outputs

Tables 1-5 provide the results of simulations of visitor use in a portion of the Humphrey's Basin area (the Desolation Lake area). The results are based on a 39 day simulation, which allows for an 11 day initialization period and 28 days of simulation output. Table 1 provides estimates of mean camping and hiking encounters per group per day corresponding to alternative total use levels of the Desolation Lake area. For example, the first row of data present results for a scenario in which there are an average of 1.8 trip starts per day from the North Lake Trailhead, 0 trip starts per day from the Lamarck Lake Trailhead, and 0.2 trips entering the Desolation Lake area per day from other locations within Humphrey's Basin. Under this scenario, the model estimates that visitors would encounter less than 1 other group per day while hiking (0.6 groups per day), and less than 1 group per night while camping (0.3 groups per night). The remaining rows of Table 1 provide estimates of mean hiking and camping encounters per group per day for increasing levels of visitor use.

Tables 2 and 3 illustrate how the Extend simulation model can be used to generate spatially explicit data concerning visitor use and encounters. In particular, Table 2 reports estimates of the average number of groups passing through each trail segment in the Desolation Lake area per day and the average number of encounters per group per

day by trail segment. Table 3 reports estimates of the average number of groups that camp within each camping zone per night and the average number of camping encounters per group per night by camping zone.

Tables 4 and 5 demonstrate how computer simulation modeling can be used to estimate the effectiveness of alternative visitor use management strategies. For example, Table 4 provides insight into the extent to which hiking and camping encounters can be reduced by redistributing visitor use evenly across the two primary trailheads into the Desolation Lake area. Table 5 provides further insight into the effects of redistributing visitor use evenly across the North Lake and Lamarck Lake trailheads. Specifically, the results indicate the extent to which visitor use of selected trail segments would change as a result of redistributing use across the two trailheads.

An in-depth, statistical comparison of the Extend simulation model outputs with the RBSim simulation model outputs is currently being conducted. Results of this analysis are forthcoming.

References

Daniel, T., & Gimblett, R. (2000). Autonomous Agents in the Park: An Introduction to the Grand Canyon River Trip Simulation Model. International Journal of Wilderness. 6(3), 39-43.

Lawson, S., Manning, R., Valliere, W., & Wang, B. (2003). Proactive Monitoring and Adaptive Management of Social Carrying Capacity in Arches National Park: An Application of Computer Simulation Modeling. Journal of Environmental Management, 68, 305-313.

Wang, B., & Manning, R. (1999). Computer Simulation Modeling for Recreation Management: A Study on Carriage Road Use in Acadia National Park, Maine, USA. Environmental Management, 23, 193-203.

Figure 1. Camping encounter zones

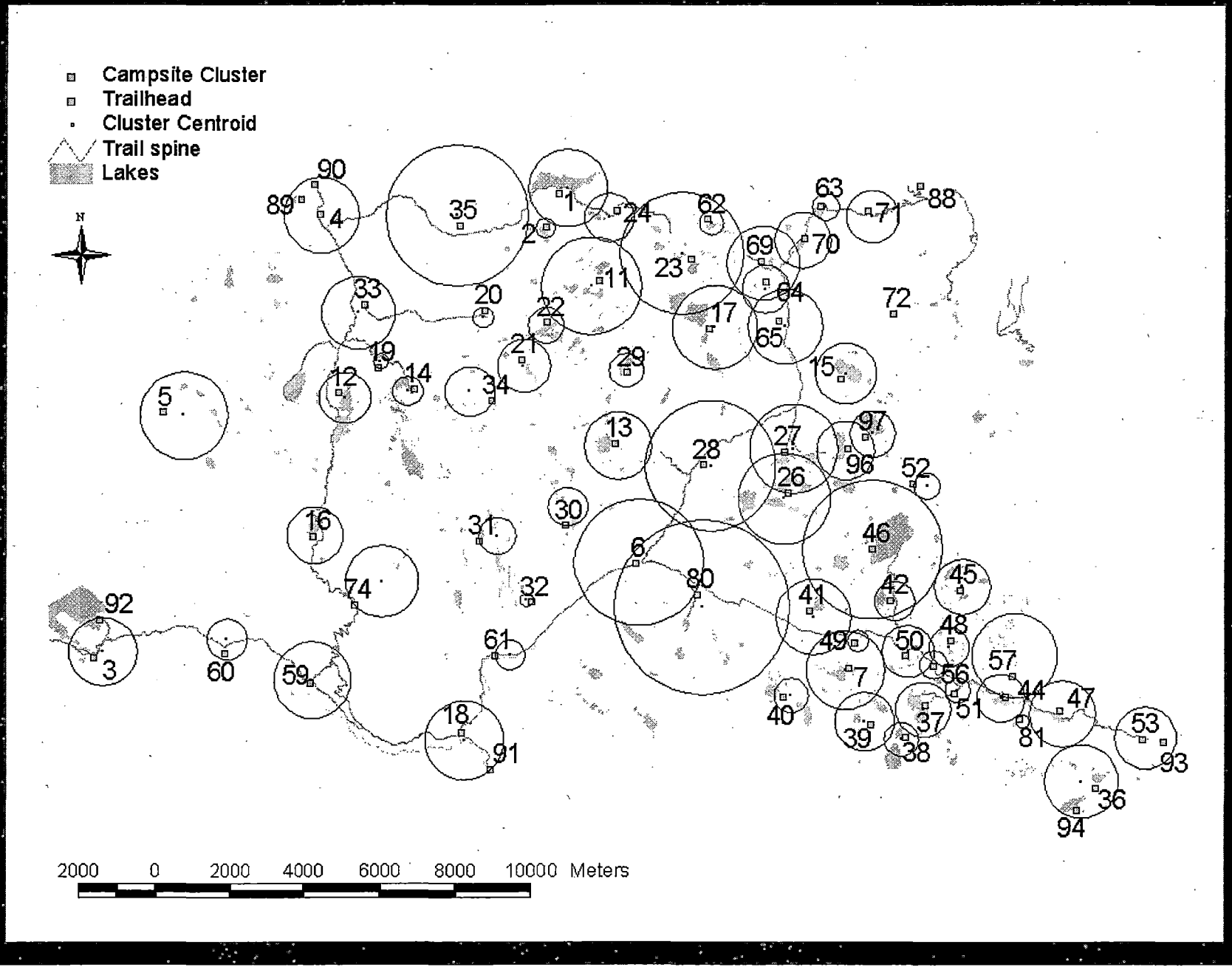

Table 1. Average hiking and camping encounters

Average Trip Starts			Hiking Encounters			Camping Encounters		
North Lake	Lamarck Lake	Other Locales	Mean	LB 95% CI	UB 95% CI	Mean	LB 95% CI	UB 95% CI
1.8	0.0	0.2	0.6	0.5	0.7	0.3	0.2	0.4
6.5	0.0	0.7	2.6	2.4	2.8	2.1	1.9	2.4
7.4	0.1	0.6	3.0	2.8	3.2	1.8	1.5	2.0
9.9	0.1	1.0	4.0	3.8	4.2	2.2	2.0	2.5
19.4	0.1	1.3	8.0	7.7	8.3	5.0	4.7	5.3

Table 2. Average Tr Use and Encounters

Trail Section	Mean Use	Mean Encounters
2	37.3	2.0
3	1.1	0.0
4	37.2	1.1
5	36.7	3.8
6	6.0	0.2
7	1.3	0.1
8	0.5	0.0
9	35.4	1.1
10	34.8	1.0
11	34.3	0.4
12	0.9	0.0
13	2.2	0.1
14	8.2	0.4
15	31.4	2.2
16	12.1	0.2
17	27.0	1.1
18	26.6	0.6
19	1.6	0.1
20	10.9	0.2
21	10.1	0.3
22	8.8	0.4
23	0.8	0.0
24	1.4	0.2
25	25.5	0.8
26	1.6	0.2
27	11.8	0.6
28	1.7	0.2
29	4.4	0.2
30	10.6	0.1
31	6.5	0.2
32	5.9	0.4
33	0.5	0.1
34	19.4	0.9
35	0.4	0.0
36	14.1	0.6
37	3.7	0.3
38	9.8	0.9
38	13.0	1.8
40	1.9	0.1
41	12.5	0.8

Table 3. Average campsite use and encounters

Campsite	Mean Use	Mean Encounters
53	0.6	
47	3.1	0.6
36	1.0	3.3
81	0.5	0.8
57	1.5	0.1
44	4.6	1.2
56	0.7	4.5
48	1.4	0.7
51	0.8	1.5
37	7.5	0.8
38	0.4	7.0
39	1.4	0.4
50		1.0
42	1.8	1.2
45	4.2	4.1
46	1.6	1.3
52	3.9	4.0
49	0.2	0.3
41	0.2	0.0
40	2.8	2.4
7	0.6	0.4
80	10.1	9.8
777	0.9	1.5
	11.4	11.0

Table 4. Spatial Redistribution of Use

	Average Trip Starts				
	North Lake	Lamarck Lake	Other Locales	Mean Hiking Encounters	Mean Camping Encounters
Status Quo	7.4	0.1	0.6	3.0*	1.8
Even Distribution	3.7	4.0	0.4	2.6*	1.8

* Significant at $\alpha = 0.01$

Table 5. Selected trail use under two scenarios

Trail Section	Status Quo		Even Distribution	
	Mean Use	Mean Encounters	Mean Use	Mean Encounters
2	13.3	0.8	6.9	0.4
4	13.3	0.5	6.9	0.2
7	0.5	0.0	6.5	0.3
8	0.4	0.0	7.6	0.5

David Cole

11/10/2003 11:06 AM

To: Susan Major/RMRS/USDAFS@FSNOTES
cc:
Subject: Re: Question on Final Report

Sue:

Yes, this report is serving as the final report for both agreements.

David

David Cole
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Susan Major

Susan Major

11/10/2003 10:36 AM

To: David Cole/RMRS/USDAFS, Jane M Richards/RMRS/USDAFS
cc: Susan Major/RMRS/USDAFS
Subject: Question on Final Report

David,

I just wanted to check with you regarding the final report you sent to us. Is the final report for both 03-JV-11222044-083 and 03-IA-11222044-076?

The one I am referencing is entitled "Simulation Modeling of Wilderness Recreation Use: Final Report Steve Lawson and Robert Manning

Your note had said you received a satisfactory final report for this RJVA, which would be 03-JV-11222044-083; but, you also said that you have supplied the NPS with an acceptable final report, which would be 03-IA-11222044-076. These two agreements, you said, were related.

Thanks for your help.

Sue

Sue Major
Clerk, Grants & Agreements
970-498-1395
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smajor@fs.fed.us

rmrs agreements <rmrs_agreements@notes.fs.fed.us>
Sent by: Susan Major <smajor@fs.fed.us>

11/06/2003 03:24 PM

To: David Cole <dcole@fs.fed.us>
cc:
Subject: Re: Termination of Agreement 03-JV-11222044-083

This final report meets the terms of the agreement.
David Cole

David,

We need two copies of the final report sent to us.

We will then send one copy to the RMRS Library and keep one copy in our file. After we get the final report, and the final invoice is paid, we initiate a close out letter to the Cooperator. After this is complete, the agreement is officially closed. The Technical Rep will receive a copy of the close out letter, so you will know when it is complete.

Let me know if this doesn't make sense.

Thanks.

Sue Major
rmrs agreements

Grants & Agreements Staff
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David Cole
<dcole@fs.fed.us>

To: rmrs agreements <rmrs_agreements@fs.fed.us>
cc:
Subject: Termination of Agreement 03-JV-11222044-083

11/06/2003 09:06 AM

I have received a copy of a satisfactory final report for this RJVA with the University of Vermont. Could you please remind me what I need to do to initiate termination of this agreement? Related to this RJVA is interagency agreement number 03-IA-11222044-076 from the National Park Service, which provided funds that were passed through to the University of Vermont. I have supplied the NPS with an acceptable final report. I'm not sure if I need do anything to close this agreement out as well.

Thank you for your help.

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